ENERGY $AVER$

"... For Business and Industry".

VOLUME 3 / NUMBER 1

REDUCE YOUR ENERGY COSTS WITH HOT GAS HEAT RECOVERY

The Facts...

Natural gas and electrical costs can be significantly reduced when waste heat from a refrigeration compressor system is recovered and recycled.

Refrigeration compressor systems remove heat from the area to be cooled and transfer it to the refrigerant in the system. The refrigerant (now a hot gas) is transferred to the condenser where it is cooled and liquefied. In many Alberta buildings, the condenser is installed on the roof which means that the substantial amount of heat given off by the refrigerant is lost to the surrounding air. By installing a heat exchanger to recover the heat, big savings in energy costs can often be realized.

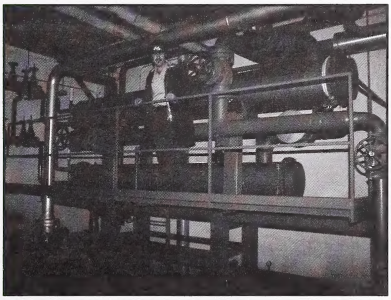
Large refrigeration systems are used extensively by the food processing industry and by recreational facilities like arenas and curling rinks. Retail stores, restaurants and hotels use smaller systems for their coolers, freezers and air conditioning.

A compressor is a device that mechanically increases the temperature and pressure of a gas or vapor. In a refrigeration system that operates on a vapor-compression cycle, there are five main components: compressor, condenser, expansion valve, evaporator and refrigerant (working fluid).

Liquid refrigerant enters the evaporator where it experiences low pressure. The low pressure causes the liquid to vaporize (or boil) and, in doing so, heat is absorbed from the area being cooled. The refrigerant leaves the evaporator as a low-pressure, relatively low-temperature vapor (gas) and enters the compressor.

The electrically-driven compressor changes the refrigerant from a low-pressure, low-temperature vapor to a high-pressure, high-temperature (superheated) vapor. An increase in temperature and pressure occurs because the vapor molecules are compacted into a fixed area within the compressor. When the temperature of the vapor is greater than the surrounding cooling medium (air or water), heat is transferred to the cooling medium.

The cooling of the refrigerant within the condenser continues until enough heat is lost to cause some vapor to again become liquid. The refrigerant leaves the condenser as a high-pressure, medium-temperature liquid and enters the expansion valve where it is transformed into a low-pressure, low-temperature vapor-liquid and returned to the evaporator to begin the cycle again.



Building maintenance staff checks heat recovery equipment.

To calculate the total heat given off by the condenser and the potential energy cost savings, the following information must be known: the operating pressure (pounds per square inch [psig]) of the compressor, the type of refrigerant, the capacity of the system (expressed in tons), the run-time of the compressor (hours per day) and the end use of the recovered heat.

Recovering and recycling heat from cooling systems in commercial, industrial and recreational facilities can help save substantially on natural gas costs. Electrical costs may also be lowered because less horsepower will be needed to operate the compressor.

The way in which recovered heat is used will vary from operation to operation. Owners and managers of large arenas that operate for a major portion of the year can use the waste heat as a snow melt for their ice-shaving system. Packing plants can preheat water for their meat-packing processes. In some buildings, heat recovered from refrigeration systems is used to preheat combustion or building air.

The Application...

Lakeside Packers is a large beef-processing plant in Brooks, Alberta. Built in 1974, the plant has a floor area of 45 360 square feet (4210 square metres).

In June 1983, management of Lakeside Packers requested an energy audit by staff of the Alberta Energy Bus audit program to help identify areas where they could save on energy consumption (natural gas and electricity) and energy costs.

The audit team predicted potential savings of about $15 000 per year in natural gas costs by reclaiming the "superheat" from compressor hot gas to preheat process water. More detailed calculations showed the following potential savings: $13 800 from superheat recovery and $49 000 from latent heat recovery for a total natural gas savings of $62 800 per year. These savings were based on a natural gas price of $2.69 per gigajoule (1983).

Superheat is the heat added to refrigerant vapor by the work of the compressor. Once a liquid is vaporized, the temperature of the resulting vapor can be further increased by the addition of heat (superheat). Latent heat is the heat that must be added or subtracted to cause a change between liquid or vapor state. This heat can be recovered when hot gases cool and condense.

At the time of the audit, the plant was recovering a small amount of the potential heat from the refrigeration hot gas. The recovered heat was used for space heating in one area of the plant.

Estimated hot water use in 1983 was about 3200 gallons per day. The plant's natural gas consumption for January to December 1983 was 25 410 gigajoules. Based on 260 working days, the natural gas consumption for heating water was 15 350 gigajoules or about 60 per cent of the annual natural gas use.

The packing plant was continually running short of process hot water. Plant management wanted to be able to heat water faster, especially after power failures and, at the same time, save on natural gas costs.

Subsequent to the audit, Heinz Woehr, manager of maintenance and construction, hired a consulting engineering firm to conduct a feasibility study on installing hot gas heat recovery equipment. The firm designed a heat-reclaim system for the refrigeration plant compressors which included a desuperheater and a condenser. Extensive improvement to the hot water storage and piping system was also recommended and under taken. The new equipment, installed and operational by August 1986, allowed reclaiming of all the superheat and a portion of the latent heat from the compressor hot gas.

At the time of the consultant's study, gas prices had dropped to $2.36 per gigajoule but the potential savings were still high enough to justify investment in heat recovery equipment.

Based on annual gas consumption data for August 1984 to July 1987 and a natural gas price of $2.36 per gigajoule, Lakeside Packers saved about $30 000 per year in natural gas costs. The total cost of the heat-reclaim equipment and installation was $80 000.

By dividing the cost of installation by the annual savings, the payback period for Lakeside Packers for their investment in heat recovery equipment can be calculated: $80 000 divided by $30 000 per year equals 2.7 years.

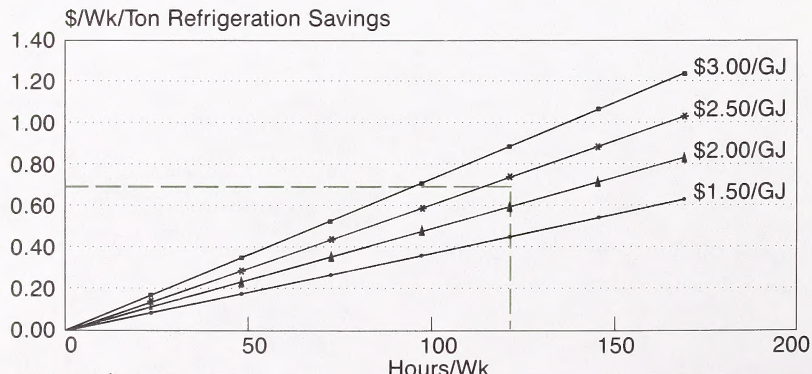
The Bottom Line...

In many facilities, refrigeration systems lose waste heat unnecessarily to the atmosphere. Installing a heat exchanger can often result in substantial energy dollar savings.

To calculate the potential savings through reclaiming superheat, the following must be known: the capacity of the refrigeration system (tons), the operating hours per week, the operating weeks per year and the natural gas cost (dollars per gigajoule).

For facilities using an ammonia system, Figure 1 can be used to determine potential savings per week per ton of capacity for recovering superheat. To calculate your approximate annual savings, multiply the savings from the graph by your refrigeration system's capacity and the operating weeks per year. The graph is based on a system with 30 pounds per square inch (psig) suction and 160 psig discharge. If your operating pressures are different, savings will vary slightly.

HOT GAS HEAT RECOVERY SUPERHEAT



- ammonia system
- 30 psig suction
- 160 psig discharge

FIGURE 1

To use the graph, find the point along the horizontal axis that matches the operating hours of your refrigeration system. Then read up to line that is closest to your natural gas cost and across to the left to get the savings per week per ton of capacity. Multiply this amount by the capacity of your system in tons and the number of weeks your system operates per year.

The green line on the graph shows the potential cost savings for the calculation example below.

To determine more accurate savings and to work out a cost estimate for equipment installation, a detailed study should be done.

The following should be taken into consideration when investigating the cost effectiveness of installing heat exchangers. These factors will affect the equipment used and, therefore, the project cost.

- end-use of the reclaimed heat
- building codes
- plumbing codes
- other provincial/municipal codes
- economics of reclaiming some of the latent heat in addition to the superheat.

Aside from the direct savings in natural gas costs, other benefits of hot gas heat recovery are:

- reduced compressor-head pressure means less horsepower required, resulting in electrical cost savings.
- cost reduction for increased condenser capacity and increased heating equipment.

Equipment costs range from $50 per ton of capacity and up, depending on code requirements. Installation costs will vary from site to site.

To determine the payback period for installing heat exchangers, divide the installation cost by the total annual savings and multiply by 12 months of the year.

EXAMPLE

Capacity of refrigerations system	200 tons
Operating hours	120 hours per week
Operating weeks	50 weeks per year
Cost of natural gas	$2.25 per gigajoule (GJ)
Savings (from the graph):	$0.66 per week per ton

Annual savings $0.66/wk./ton × 200 tons × 50 wks. $6600 per year.

SECTOR REVIEW

Energy Use in the Food Processing Industry

Energy use varies widely, depending on the type of building and the activities in that building. The extent of variation in energy use has become evident following Energy Bus audits of almost every type of facility in Alberta.

An energy audit determines initially how energy is being used and how much it costs in each area. Energy conservation measures are then identified which can result in energy cost savings. On average, the Energy Bus has identified a potential reduction in energy costs of about 20 per cent.

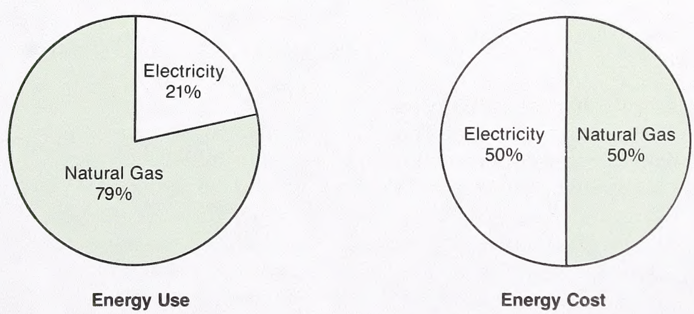
The food processing industry includes subsectors such as meat, poultry and dairy products. This is an energy-intensive sector because considerable amounts of electricity and natural gas are required to process products.

Energy audits of 14 food processing facilities by staff of Alberta's Energy Bus audit program have shown there is good potential for energy cost savings in this sector. The total energy use and cost at these 14 facilities is about $4 million annually.

Figure 2 shows the breakdown of energy use and cost for electricity

FIGURE 2

Energy Use and Cost in Food Processing Industry



and natural gas in the food processing sector. Electrical use is the lowest, only 21 per cent compared with 79 per cent for natural gas. However, electricity is a major cost area, accounting for 50 per cent of the total energy cost in this sector. There is a difference in the percentage of energy used and its associated cost because the average price of a unit of electricity is four to five times that of the equivalent unit of natural gas.

Figure 3 indicates the areas of energy use for food processing facilities. Most of the energy (electricity and natural gas) is used in the process portion of the overall operation.

The potential for natural gas savings through heat recovery from compressor hot gas was identified in seven of the 14 audited facilities.

In the 14 processing facilities, the total potential saving was identified at approximately $600 000 per year - 69 per cent of these savings being associated with natural gas use. As shown in Figure 4, compressor hot gas heat recovery is a major component of the potential savings, representing 52 per cent of the total natural gas savings identified.

FIGURE 3

Energy Use in Food Processing Industry

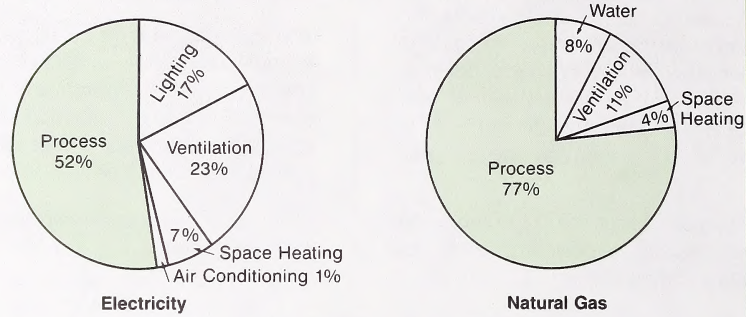
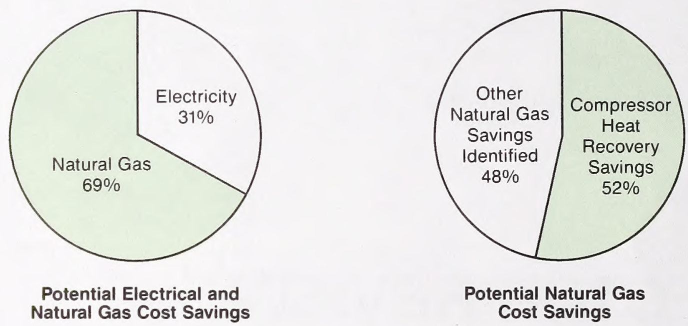


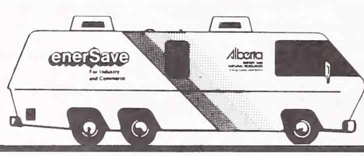
FIGURE 4

Potential for Savings in Food Processing Industry



FOR MORE INFORMATION

The article *Reduce your Energy Costs with Hot Gas Heat Recovery* was researched by Brian Weir, who also completed the Sector Review. For detailed information on energy cost-saving calculations and the energy audit database, contact the technical services section of the Energy Efficiency Branch: Phone 427-5200 (collect).



ENERGY $AVER$

Energy $aver$ is a series of fact sheets about energy conservation measures that have wide application in Alberta. Each issue highlights a different technology and its successful use in the province. The Sector Review summarizes energy use patterns of different facilities that have used Alberta's Energy Bus audit service. Comments, questions, and suggestions are welcome.

Write or phone (collect) to be placed on the mailing list. You may also receive back issues or arrange for an Energy Bus audit (conducted at no charge).

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